

National Aeronautics and Space Administration

**SEARCH FOR EARTH-LIKE PLANETS
STRATEGIC ROADMAP COMMITTEE**

May 16–17, 2005

**Crowne Plaza Hotel
Seattle, Washington**

MEETING REPORT

Ghassem Asrar
Co-Chair

Adam Burrows
Co-Chair

David Spergel
Co-Chair

Eric Smith
Designated Federal Official

Search for Earth-like Planets Strategic Roadmap Committee

May 16–17, 2005
Crowne Plaza Hotel
Seattle, Washington

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***Meeting Report Prepared by:
Robert J. Katt, Consultant
INFONETIC***

Search for Earth-like Planets Strategic Roadmap Committee

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Monday, May 16, 2005

Meeting Opening

Adam Burrows, co-chair of the Search for Earth-Like Planets Strategic Roadmap (Earth-Like Planets SRM) Committee, opened the meeting at 8:30 a.m. David Spergel and Geoff Marcy joined the meeting by telephone. Dr. Burrows reviewed the objectives and agenda for the meeting.

Strategic Process Update

Eric Smith, the Designated Federal Official for the committee, reviewed the procedure for a public meeting under the Federal Advisory Committee Act (FACA). He then updated the committee on changes to the strategic roadmapping process since the prior meeting in March. The new NASA Administrator, Dr. Michael Griffin, has moved the date for completing the individual roadmap narratives up to May 23. The six strategic roadmaps being led by the Science Mission Directorate (SMD), including this one, will go to the National Academies/National Research Council (NRC) for review. The other strategic roadmaps will not be completed in time and will not be reviewed by the NRC in the same time frame. SMD staff will use the six roadmaps to build an integrated science story for the directorate's programs and future direction. The team working on the integration will include Wes Traub and Michael Werner, who will be able to represent the planet-finding community.

Ghassem Asrar added that the work of the six SRM committees will be used to define what the SMD will be doing over the next several decades. The integration process will define unified priorities and objectives for the directorate. Specifically, the results will provide input to the fiscal year (FY) 2007 budget preparation process. The NASA Administrator wants the NRC review to ensure that NASA's plans are consistent with the national priorities established in NRC reports and other community-reviewed studies. Dr. Griffin wants programs and objectives to be well defined. Current programs and priorities will be preserved for the remainder of the decade. However, he expects the SMD to define its programs and priorities and manage the near-term challenges to achieving them within the anticipated SMD budget. He is willing to consider budget realignments among the three divisions in the SMD. The Office of the Administrator has taken charge of planning the process for the remainder of Agency-wide strategic planning, including Shuttle Return to Flight and eventual retirement of the Shuttle, the International Space Station (ISS) program, next-generation launch vehicles, and the human exploration programs. Dr. Griffin would like to get the proposed Crew Exploration Vehicle (CEV) developed, tested, and in use sooner than previously planned.

There will be some difficult choices to make, as with the servicing mission to the Hubble Space Telescope (HST). Cost growth in projects will have to be addressed within existing directorate budgets. Work is in progress within NASA on the FY 2007 budget proposal. The draft proposal will be iterated with the Administration before the final version goes to Congress. Dr. Asrar said the SRM and Agency transformation process continues to be dynamic. He emphasized that NASA leadership is committed to keeping its communities of interest informed about what is happening, but he admitted that the pace of change and planning activities makes it difficult to keep that communication current all the time.

At Dr. Burrows' request, Dr. Asrar discussed a statement by the NASA Administrator on the possibility of delaying the Space Interferometry Mission (SIM) and the Terrestrial Planet Finder (TPF) program to provide additional budget resources for an HST servicing mission. Dr. Asrar said that various proposals have been framed for dealing with problems in SMD programs. However, no consideration is being given to moving funding from SMD to exploration activities outside the directorate. David Spergel commented (by telephone) that the recent renewed emphasis on HST servicing relative to exploration priorities such as the planet-finding goal seems to be a step backward in moving toward implementation of the Exploration Vision. With respect to the relative priority of competing goals, he noted that the NRC decadal surveys have never ranked a continuation of HST beyond its primary mission period against the opportunity cost of foregoing future missions such as SIM or TPF. Frank Martin gave his view of the direction taken by Dr. Griffin, saying that it shows an understanding of what is needed to move the Agency forward. Dr. Asrar agreed that the concerns of the science community about servicing HST were not initially framed in terms of trading a servicing mission against other priorities. He said that Dr. Griffin sees the science missions as one of the crown jewels of NASA, which should not be sacrificed to address problems in other areas. However, without new money beyond the current long-term plan, hard choices among priorities will be necessary. Tom Greene suggested that NASA should apply its time-proven Senior Review approach to weighing the opportunity costs of extending HST, as well as other highly successful missions that are currently operating.

Dr. Smith stated that Maureen Heath and John Mather will recuse themselves if the James Webb Space Telescope (JWST) is discussed during the committee's deliberations. Ms. Heath will also recuse herself when SIM is discussed.

Session 1. Roadmap Review and Discussion: Outstanding Issues

Dr. Burrows led the committee in reviewing the latest draft material for the roadmap report, distributed on May 9. Major points to address were the branch points and pathways, such as the pathway if the frequency of Earth-like planets is high (i.e., if the ratio of Earth-like planets to stars, or η_{Earth} , is close to 1). He said the argument for SIM's effect on TPF efficiency also will need to be improved. Because the desired length for the body of the report is about 40 pages, the committee worked with the larger draft version from May 9.

Dr. Burrows began with several smaller but less controversial issues that could be quickly resolved. The first of these was whether to keep the Planet Imager mission concept in the roadmap as a technology driver or delete it. Dr. Greene favored deleting it if there was a need to cut text to meet the page limit, but otherwise it would be useful to mention Planet Finder as setting a stake for the future, even though the enabling technology is still "pie in the sky." Jerry Chodil also favored mentioning Planet Finder as an objective and a vision for the future. Care should be taken, he said, in stating anything about the enabling capabilities. Victoria Meadows said that she had difficulty in justifying Planet Finder scientifically. She agreed that a vision direction is needed after the Life Finder mission. However, the Planet Imager discussion currently takes too much space in the draft and should be downplayed relative to Life Finder. Dr. Martin agreed with Mr. Chodil. Dr. Marcy expressed concern about the credibility of the rest of the document if Planet Imager is viewed as too fantastic to be credible. Dr. Spergel agreed with the suggestion made by other members to keep Planet Imager in the roadmap as a long-term goal, but with minimal commitment or specification of capabilities required for it.

Dr. Burrows asked Charles Beichman (providing expert support to the SRM committee) for comment. Dr. Beichman described the provenance of the Planet Imager concept and suggested

mentioning it as part of a long-term vision but excluding it from the detailed tables on the near- and mid-term missions to preserve credibility. He agreed with others that the Life Finder mission is more defensible. There was further discussion of how to address capability development for Planet Imager. Dr. Asrar and Dr. Meadows discussed and eventually agreed on the scientific potential for spatially resolved spectral data. The committee agreed to delete Planet Imager from Figure 4-1 in the draft but retain it in Table 4-1. The text will be reviewed to ensure the concept is presented as a future vision that is not yet defined.

The second issue discussed was the set of time periods and the anticipated mission dates to be used in the roadmap. For example, should the coronagraphic TPF mission (TPF-C) be put in the mid-term, 2015–2024 period, rather than the near-term period (2005–2014)? After discussion of the pros and cons of placing it in one period or the other, the committee agreed to keep the dates as they are in the May 9 draft, with TPF-C in the middle period and an anticipated launch in 2015.

The third issue discussed was the argument for SIM as enhancing the efficiency of the TPF missions, particularly TPF-C. Dr. Spergel suggested couching the relationship in terms of the tremendous scientific synergy between the two missions and the value in having some operational overlap. This rationale differs from the efficiency argument and avoids the implication that TPF-C planning should be delayed until all the SIM data are in hand. SIM data cannot be used, Dr. Spergel said, to decide not to observe a star with TPF-C, if that star is otherwise a candidate. Dr. Marcy agreed with the strength of the synergy argument. He noted, however, that SIM will produce results at two levels of probability of detection. (See notes from the March 29–30 meeting for details.) The crux of the matter, he said, is that the final TPF-C requirements and capabilities are not yet definite, whereas SIM's astrometric precision has now been determined more concretely through its development process. The capability statements made for the two missions do not have the same degree of empirical validation. In response to Dr. Spergel's argument that TPF-C spectroscopy will be more difficult than imaging, Dr. Marcy suggested that Dr. Spergel's points provide a clear science-floor requirement for TPF-C. Drs. Meadows, Martin, and Spergel commented further on the argument for synergy with respect to early TPF-C targets and SIM data on them, rather than arguing for efficiency in terms of the total number of planets that would be found with TPF-C. At Dr. Burrows request, Dr. Beichman reviewed details of a planet imaging search by either SIM or TPF-C and how those characteristics relate to the synergy between SIM and TPF-C. The committee discussed focusing the argument on improvements in TPF-C results in its first years, which can be anticipated if SIM results are available to prioritize that early period, as opposed to a claim about the total number of planets TPF-C is expected to find over its full mission life. As Dr. Spergel summarized the point, TPF-C will be working in a target-limited regime defined by its inner working angle capability, and that constraint is more likely to determine the total number of planets it finds. Dr. Burrows agreed to draft provisional language expressing the near-term productivity argument, to be reviewed on the second day by the committee. He asked the entire committee to review the draft text that currently discusses the efficiency or synergy of the two missions.

The fourth issue discussed was how much importance to give to having operational overlap between SIM and TPF-C, to get the greatest science synergy. A key point is that, even after SIM's observational lifetime ends, the data archived from it can be analyzed to find astrometric evidence for a planetary mass orbiting a star identified by TPF-C as a candidate of interest.

Session 2. Roadmap Review and Discussion: Review of Members' Comments

Dr. Burrows led a review of additional issues that had been raised by committee members prior to this meeting and their status in the current draft. In response to Mr. Chodil, he said that minor edits still to be made would be collected during the second day's sessions, once the discussion of substantive issues was completed. One issue discussed was whether the roadmap should be more specific about research and analysis (R&A) areas that are important for the Earth-Like Planets SRM. Other topics reviewed were the extent of reference to the Navigator Program in the draft, whether to include the Stratospheric Observatory for Infrared Astronomy (SOFIA) mission in Figure 4-1, whether to include a far-infrared space interferometer mission concept in the roadmap's far-term period, and the coverage to be given to exploration of habitability as opposed to planet identification. After discussion of these issues, several members agreed to draft specific changes for review on Tuesday. Dr. Meadows agreed to work on rewording for the section on indicators of life. The committee discussed and agreed on content and format changes to the table of missions that will address habitability and indicators of life.

After reviewing the assignments for edits and revisions, Dr. Burrows led the committee in a preliminary discussion of key decision points leading to alternate pathways. The committee considered descriptions of technology breakthroughs that could affect roadmap pathways.

Session 3. Roadmap Review and Discussion: Decision Points and Alternate Pathways

After a break for lunch, the committee reviewed in detail the text on branch points and alternate pathways in the May 9 draft (section 4). The members discussed how far to expand the range of "what if" options presented in the roadmap. Dr. Asrar said that this section of the roadmap report was intended to convey two messages. First, it should present the science community's view on what should be done if a major program change is required (e.g., because critical technology is not ready or a major science result changes priorities). For this purpose, the branch points should be strategic, not tactical. Second, it will be used to communicate to sponsors (Congress and the interested public) that what NASA does is risky. In light of these risks, the planners have considered what to do in case of a major failure or upset in the pathway to achieve a strategic goal.

The members discussed how to use the first table as the basis for discussing the response to a major mission failure—for example, if the SIM spacecraft and its unique measurements of planetary masses were lost. There was general agreement that the current set of roadmap alternatives already provides adequate robustness. Dr. Burrows asked the committee to review the text on consequences of an early failure of TPF-C. Revisions were discussed that would capture the need to change the requirements for the Life Finder mission, if TPF-C could not fulfill its primary mission. During the discussion, Dr. Beichman proposed that the overall goal for finding Earth-like terrestrial planets can be expressed in terms of needing three kinds of observations on candidate planetary systems (or candidate stars that might have such systems): visible-light photons, infrared photons, and observations on planetary mass. He discussed with the committee members how the alternative pathways could be used to show mitigation of risks to this broad program requirement, if any particular mission were to fail to meet its intended objectives.

Next, the committee discussed the pathway option if the Kepler mission shows that η_{Earth} is close to unity and whether this result would make a strategic difference in the program. The members agreed to say, at a general level, that the planet characterization effort would increase and might be implemented by several approaches. Drs. Meadows and Beichman agreed to draft a paragraph on the programmatic response to η_{Earth} being close to unity. If, by contrast, η_{Earth} were shown to be only 1 percent, then the interferometric TPF mission (TPF-I) should be done before TPF-C

because the survey of candidate stars would need to extend further (to higher redshifts). Drafting assignments were made to capture the conclusions from the committee discussion in text for the roadmap. The committee agreed that a sentence or two on the Gaia mission should be included in the draft. Assignments were made for members to review and revise the existing text on branch points resulting from a technological breakthrough that causes program priorities to be rethought. The committee discussed whether an Executive Summary should be written as a stand-alone document. Updates to the table of expected achievements (Table 4-1) were discussed.

Session 4. Public Input

No requests for public input were presented to the Designated Federal Official or the co-chairs.

Session 5. Roadmap Review and Discussion—Continued

Dr. Burrows led the committee's review of revisions drafted by various members in response to the morning's discussions on SIM–TPF synergy and efficiency. The Committee discussed corrections and additions to Table 4-1 and agreed on additional changes. Dr. Meadows led a review of her revisions for the text on the TPF missions as providing potential initial indications of biosignatures. Life Finder will provide more detailed characterization of biosignatures, with the intent of giving an unambiguous signal of biosignatures and a characterization of habitability-related conditions. Changes were agreed upon to distinguish the capabilities of the TPF missions from those of a subsequent Life Finder mission.

The committee discussed the graphics and figures in the May 9 draft and agreed on several deletions, replacements, and revisions. Edit suggestions from the members were discussed, and the approved changes were incorporated in the working draft. Dr. Burrows adjourned the session for the day.

Tuesday, May 17, 2005

Session 6. Roadmap Review and Discussion—Continued

Geoff Marcy, Edna DeVore, and Neil Tyson participated in this session by telephone. Eric Smith asked the committee to consider whether in-space assembly was an enabling technology capability for planet-finding missions. The committee agreed that such capability could be important for the Life Finder mission but was not relevant for the planet-finding mission sequence through TPF-I.

Dr. Burrows reviewed the work still to be done in revising the draft. He asked the committee again about the value of an Executive Summary for the document. A separate summary need not be completed by the due date of the report. Committee members generally favored a one-page (2 sides) Executive Summary. The committee discussed different forms and purposes for a summary, including a two-page summary to go at the front of the document and a brochure-style separate document. The committee then reviewed and discussed, as a basis for further revision, a draft summary that Dr. Burrows had modified from a version he prepared for the legacy Universe Division roadmap. Graphics and visuals for the roadmap were discussed, as well as the audiences toward whom it should be directed.

The committee then reviewed and accepted or corrected text revisions prepared overnight by Dr. Burrows and other members. There was extensive discussion of, and further changes to, the appendix revisions suggested by Dr. Asrar. The draft text related to the branch points if η_{Earth} is

either large (close to unity or higher) or small were discussed in detail and revised. The latest version of the Expected Scientific Achievements table was reviewed.

Wrap-Up and Closing

Dr. Asrar thanked the members for participating in the roadmapping process and for their work on the Search for Earth-Like Planets SRM. He said the roadmap would be used by the leadership of SMD and NASA to chart the course of the Agency's programs over the coming decades. Dr. Spergel noted that he will use material from the final document for a presentation to the NRC review panel. Dr. Burrows will distribute a final review draft to the committee members for review within the next several days. The meeting was adjourned at 11:30 a.m. PDT.

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Agenda

Day 1

8:00 a.m.	Continental Breakfast	
8:30	Meeting Opening Strategic Roadmapping Process Update	(NASA)
9:00	Session 1: Roadmap Review and Discussion: Section 2 & 3	
10:30	Break	
10:45	Session 2: Roadmap Review and Discussion: Section 4 & 5	
12:00 pm	Lunch	
1:30	Session 3: Roadmap Review and Discussion: Sections 6 & Appendices	
3:00	Break	
3:15	Session 4: Public Input session	
3:45	Session 5: Roadmap Review and Discussion: Graphics Review	
4:15	Session 6: Science Roadmap Integration	(NASA)
4:30	Session 7: Assignments for Roadmap final production	
~6:30	Dinner	

Day 2

8:00 a.m.	Continental Breakfast	
8:30	Session 8: Linking Roadmap to Universe Division Roadmap	
12:00 pm	Lunch and meeting adjourns	

Search for Earth-like Planets Strategic Roadmap Committee
Committee Roster

Ghassem Asrar *co-chair*
Deputy Associate Administrator, Science
Mission Directorate, NASA

Adam Burrows, *co-chair*
University of Arizona

David Spergel, *co-chair*
Princeton University

Gerald Chodil
Ball Aerospace (*retired*)

Tom Greene
NASA Ames Research Center

Maureen Heath
Northrop Grumman Space Technology

Geoff Marcy
University of California, Berkeley

Frank Martin
Lockheed Martin (*retired*)

John Mather
NASA Goddard Space Flight Center

Victoria Meadows
Spitzer Science Center, California Institute
of Technology

Neil Tyson
American Museum of Natural History

Alycia Weinberger
Observatories of the Carnegie Institution of
Washington

Rich Capps
APIO Coordinator
Jet Propulsion Laboratory

Eric P. Smith
Directorate Coordinator and Designated
Federal Official
Science Mission Directorate
NASA Headquarters
300 E. Street, S.W. Mail Suite 3W39
Washington, D.C. 20546-0001
Tel: 202-358-2439
Fax: 202-358-3096
Email: Eric.P.Smith@nasa.gov

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MEETING ATTENDEES

Committee Members:

Asrar, Ghassem, <i>co-chair</i>	NASA Headquarters
Burrows, Adam, <i>co-chair</i>	University of Arizona
Spergel, David, <i>co-chair (by telephone)</i>	Princeton University
Greene, Thomas	NASA Ames Research Center
Marcy, Geoff (<i>by telephone</i>)	University of California, Berkeley
Martin, Frank	retired
Mather, John	NASA Goddard Space Flight Center
Meadows, Victoria	NASA/JPL
Smith, Eric, <i>Designated Federal Official</i>	NASA Headquarters
Tyson, Neil (<i>by telephone</i>)	American Museum of Natural History

NASA Attendees:

Capps, Rich	NASA/JPL
Devirian, Michael	NASA/JPL
Heap, Sally	NASA/GSFC
Lapiana, Lia	NASA Headquarters

Other Attendees:

DeVore, Edna (<i>by telephone</i>)	SETI Institute (<i>ex officio</i> committee member)
Katt, Robert	INFONETIC

LIST OF PRESENTATION MATERIAL

There were no presentation materials distributed to the committee at this meeting.